Laurent Vanbever My research goal? Automate, 1 network at the time.



Currently	Assistant prof. @ETHZ
Before	Post-doc @Princeton U
Before	PhD @UCL Belgium

"SDN" with a twist

Develop a complete & sound network controller which can automatically enforces high-level requirements



Introduction Slides

Alexander von Gernler

<gernler@genua.de>

Munich Internet Research Retreat Raitenhaslach, November 24, 2016 Alexander von Gernler

genua

Alexander von Gernler

- Head of Research at genua GmbH

 Post Quantum Crypto, FPGA Packet Filters, Advanced Persistent Threats, Software Defined Networking, Security in Critical Infrastructures, Micro- and Separation Kernels, ...

- GI Junior Fellow

- 1. Networking between OpenSource und Academia Communities
- 2. Effort for more efficient Funding of Research
- 3. IT Security and Privacy post-Snowden
- OpenSource Hobbyist
 - OpenBSD-Committer 2005-2010
 - -- \$ ssh -o 'VisualHostKey yes'. Did it.


```
The authenticity of host

RSA key fingerprint is 94

+--[RSA 2048]---+

| ...oo |

| o... * |

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| ... + o . |

| ... |
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genua

About genua

- IT security company
 - founded in 1992
 - Kirchheim bei München
 - 240 employees (October 2016)
 - part of Bundesdruckerei group since August 2015
- Firewalls, VPN-Gateways, Fernwartung
 - packet filters, application level gateways
 - OpenBSD-based
 - certified by German BSI: Common Criteria, EAL4+
- Reference Customers
 - MAN, RTL II, Hypo-Vereinsbank, Klüber, ...
 - BSI, Generalbundesanwalt, Stadt München, Bundeswehr, ...

TUM LKN: Arsany Basta

Next Generation Mobile Core Network based on SDN, NFV and NV

Motivation

- Current mobile core network built out of dedicated hardware
- Inflexible and induces high cost to setup and maintain
- →investigate concepts of SDN, NFV and NV at the mobile core

Approach

- design and model the resources dimensioning of the mobile core, based on SDN and NFV [1-2]
- develop SDN virtualization solutions to provide

flexible, resilable and dynamic slices towards 5G [3-4]

^[2] A Basta et al., Applying NFV and SDN to LTE Mobile Core Gateways; The Functions Placement Problem, ACM SIGCOMM ATC, 2014

- [3] A. Basta et al., HyperFlex: Demonstrating Control-plane Isolation for Virtual Software-Defined Networks, IM, 2015
- [4] A. Basta et al., Towards a Dynamic SDN Virtualization Layer: Control Path Migration Protocol, CNSM ManSDN/NFV, 2015

TUM LKN: Arsany Basta

Next Generation Mobile Core Network based on SDN, NFV and NV

Research Questions

- resource optimization, i.e., controllers, data centers, vms, ..?
- measurements and observations of NFV and SDN prototypes?
- solutions for reliable SDN virtualization layer?
- SDN virtualization layer to cope with network dynamics?
- check out "HyperFlex "SDN virtualization Poster
 - HyperFlex design goals
 - HyperFlex features
 - HyperFlex demos
 - HyperFlex open questions

About myself

Professional Background

- Director of Future Network Technologies at Huawei ERC, Munich.
- Associate Professor and Network Security research leader at the Computer Science and Networking Department of Telecom ParisTech, France.
- PhD in network security (ENST, Paris), Dipl.inform. (University of Karlsruhe).

Current Research Interests

- 5G Mobile Core Network
- Programmable network infrastructures
 - Not "Network as a Service", rather "Network infrastructure as a Cloud"
- Support of critical services in software networks
- Resilience of software networks

Artur Hecker Huawei ERC, Munich

Open Questions

- How to support critical and massive MTC in 5G?
 - Critical => reservations => state vs. massive => scalable => no state
- Multi-domain operations with software networks
 - □ Let Network *a* have behavior *A* and Network *b* behavior *B*. Roaming from *a* to *b*???
- Software Network Management
 - How can one design a scalable management system for a software network, the behavior of which is not clear at the moment of its deployment?
- Software Network Control Problem
 - How can one design a resilient network control system for a software network without severely limiting its programmability?

My Research Interests

Claas Lorenz

<claas.lorenz@genua.de>

- IT-Security Researcher with genua
- -- Currently working on SDN/NFV-Security in the BMBF project SarDiNe
- Research Interests:
 - Firewalling in General
 - Security Policy Enforcement in virtualized Environments
 - Hardware Acceleration in SDN/NFV
 - Formal Security Policy Verification

Research Questions

- -- What Security Properties can be achieved in Virtualized Network Environments?
- Are there fundamental Limitations?
- -- What are the Chances introduced by Network Virtualization?

Introduction & Research

- Edwin Cordeiro
- Chair of Network Architectures and Services

- Real-time Automated Traffic Engineering
- Congestion Detection in the Internet
- Software Defined Networks
- Interface to the Routing System (I2RS)

- Impact of automated traffic engineering in current network protocols
- Detecting congestion without a probe at the destination
 - Parameters and thresholds to detect congestion in the Internet
 - Building a "ground truth" propagation time for a new destination
 - Low bandwidth utilization
- I2RS implementation
 - Understanding Quagga architecture to properly add I2RS to it
 - Analysis of YANG data models proposed by the working group

Research

Florian Westphal 4096R/AD5FF600 fw@strlen.de 80A9 20C5 B203 E069 F586 AE9F 7091 A8D9 AD5F F600 Networking Services Team Red Hat

- Linux nftables network vm (similar to bpf)
 - provides 'building blocks' for packet/flow classification
 - frontend tool (nft) to allow adding filters, traffic accounting, policing, ...
- extend it to provide programmable network stack/forwarding plane
- Linux network stack parallelization & scalability
 - RCU-ification (lockless data structures)
 - percpu data only when needed
 - be cache friendly

Open Questions

- Legacy and deployment issues
 - ECN
 - UDP (encap) everywhere, implications?
- consider implementation issues during protocol design
- improve research vs. standardization vs. deployment
 - IKE, Datacenter TCP, ...

Research

Software Defined Radio

- Full stack research & development
- PHY, MAC, Security, IP and upper layers

TCP Traffic Optimizer

- Live analysis on flow basis
- Duplicate checks, reordering and SACK optimizations
- Keepalive packets to keep connections alive

Mobile AdHoc Network Protocol

- Similar to OLSR
- Implemented in MAC layer, bit packed
- Metric extensions
- Dynamic Intervals based on network characteristics

Hagen Paul Pfeifer hagen@jauu.net Rohde & Schwarz, Munich Secure Communications

Decentralized Time Management Protocol

- For Mobile AdHoc Networks, no preconfigured master node supporting network merge and splitting
- Accuracy of <20 µs

. . .

Path delay detection and compensation up to 200 nmi

Active Queue Management Packet Classification Engine (similar to BPF)

Open Questions

Multilink Routing Protocol for MANETs

- Interior MANET protocols works quite well!
- How to connect several (e.g. hundreds) MANETs? Networks of MANETs ("BGP for MANETs")

- Dynamic environment, IP prefixes change permanently, terminals come and go (no static BGP setup)
- Load-sharing is a requirement policy based routing

Reliable Multicast Pub/Sub Framework with Policy based Congestion Control/Transmission Mechanisms

 Think of MQTT/ZEROMQ for larger, multi-hop networks with fluctuating channel characteristics

- Reliable characteristics required via retransmission
- Dynamic switching to TCP when only one subscriber is available

Rolf Winter

Current Research Interests

- Network Measurements
- Network Troubleshooting
- Robust Internet Access

Hochschule Augsburg University of Applied Sciences

Research

ШП

- Work Experience =
 - 2016: Postdoc at TU Munich, Jörg Ott
 - 2007~2016: Postdoc, PhD, Project researcher at Univ. Helsinki
 - 2014 at Columbia University, Henning Schulzrinne, New York, USA
 - 2013 at Cambridge University, Jon Crowcroft, Cambridge, UK
 - 2012 at Deutsche Telekom Labs, Ben Hui, Berlin, Germany
 - Mobile offloading, IoT security and privacy

UNIVERSITY OF

CAMBRIDGE

IoT Security... as a Service?

- Securebox project
 ACM CoNEXT CAN '16
- Does it work?
- How to enable it in a cost-efficient way?
 - Implementation and Experiment
 - Observations and Lessons
- Is this actually a problem?

Dirk Kutscher

- CTO for Virtual Network Engine at Huawei German Research Center
- Platforms, architectures and applications for programmable networks
- Cloudifying telco and enterprise networks
- Evolving the Internet from circuits towards a platform for data access and dynamic computation
- IRTF ICNRG

Topics of Interest

- Performance in the presence of heterogeneity and dynamic network conditions
- Rethinking collaboration of apps, transport and forwarding
- New forwarding abstractions and SDN control for that
- Enabling dynamic computation in the network securely
- Use cases: IoT, blending VoD and live streaming

Mirja Kühlewind

Post-Doc at ETH Zurich Networked Systems Group (NSG) IETF transport Area Director & IRTF maprg co-chair

Work area(s): transport protocols, Internet measurement, middlebox cooperation, congestion control/ECN, low latency support

EU-ICT MAMI Project (Jan'16 - Jul'18): <u>https://mami-project.eu/</u> "Measurement and Architecture for a Middleboxed Internet"

Large-Scale measurement of middlebox impairments: how bad is it? • PATH**spider**: <u>https://pathspider.net/</u>

• Path Transparency Observatory (available end of 2016)

Path layer for transport-independent signaling & state management Middlebox Cooperation Protocol (MCP)

Flexible Transport Layer (FTL): path selection and encryption

Open questions

- How to enable deployment of new (transport) protocols?
- How to select the right transport service (e.g. congestion control and reliability) for an application and for a certain path?
- How to enable ubiquitous encryption (incl. transport) while keeping the network manageable?
- How to share crypto context between different layers (over certain time frames)?
- How to provide better in-band measurement/monitoring facilities e.g. for network trouble-shooting?

TUM Chair of Communication Networks (LKN) Wolfgang Kellerer

TUM LKN: Wolfgang Kellerer

Flexibility as a Network Design Guideline

Research questions

- How to cope with the emerging network dynamics?
- How to design a network for flexibility?
- What is the role of virtualization and SDN?
- How can we use "flexibility" as a measure to compare different system designs?

POSTER and TALK later today

European Research Council Established by the European Commission

Initial Flexibility Analysis: **Delay-aware Placement in DC**

 $(\sum \sum feasibleSol_{i,j} * w_{i,j}) / (\sum \sum w_{i,j})$ (1)

W. Kellerer, A. Basta, A. Blenk, Using a Flexibility Measure for Network Design Space Analysis of SDN and NFV. SWFAN'16, IEEE INFOCOM Workshop, April 2016.

HyperFlex a flexible SDN Hypervisor

Concept

- adapt based on vSDN requirements. dynamics, objectives
- control and data isolation
- combined HW and SW solution
- function chaining

A. Blenk, A. Basta, W. Kellerer, HyperFlex; An SDN Virtualization Architecture with Flexible Hypervisor Functio Allocation, IFIP/IEEE IM, Ottawa, Canada, Mai 2015.

TUM LKN: Raphael Durner

Network Security with NFV and SDN

Scenario:

- SDN and NFV in Campus and Business Networks
- Firewall moves from the edge of the network to the inside → virtualized firewall everywhere

Known:

- Network-Functions can be run virtualized in a local or remote cloud
- SDN changes connectivity approach from "allow-first-restrict-later" to "restrict-first-allow-later"

Figure: SDN with VNFs on the example of Firewalls. The firewall could be NFV-only, SDN-only or a combined approach

TUM LKN: Raphael Durner

Network Security with NFV and SDN

Research questions:

- How to combine SDN and NFV efficiently
 - SDN-only NFV
 - Plain NFV with SDN for load-balancing
 - Hybrid NFV combines both
- What new attack vectors result from SDN
 - e.g. separation of Control and Data Plane can make a black hole network attack possible

POSTER The Cost of Security in the SDN Control Plane:

- Cost of employing TLS with OpenFlow
- Support of TLS in the OpenFlow

Brian Trammell

- Senior Researcher (80%) Networked Systems Group, ETH Zürich
- Architecture Evangelist (20%) Network Security Group, ETH Zürich
- Measurement of *Internet path transparency* and deployability of new (layer 4+) protocols (H2020 MAMI).
- Transport stack re-architecture: new interfaces for *explicitly multipath* connectivity and explicit cooperation with devices on path (H2020 MAMI).
- Future infrastructures for Internet naming and incremental deployment of an FIA (<u>scion-architecture.net</u>).

Open question

- Is there still room for "Internet architecture" as a practice: how can we transition research-derived technologies on to the Internet on purpose?
 - This is as much a question of economics and the accidents of history as the fundamental properties of the technologies themselves.

Nokia Bell Labs Munich

End to End Mobile Network Solutions Research

- Dr. Marco Hoffmann
 - Technology Manager for Softwarization
 - Project Manager of Celtic+ SENDATE
- Dr. Rastin Pries
 - Senior Research Engineer Mobile Network 5G
- Research topics
 - 5G architecture
 - Network slicing
 - Network Function Virtualization and placement
 - Distributed Cloud
 - Security

Open Questions

NOKIA Bell Labs

Introduction & Research

- Daniel Raumer
- Chair of Network Architectures and Services

- · Testbed for performance measurements
- Software-based network components

Open Questions

 Improving the scientific workflow within the Baltikum testbed; including automation, documentation, ease of use, reproducibility, quality

- Performance measurements within the testbed
- Combination of models and measurements

Introduction & Research

- Paul Emmerich
- Chair of Network Architectures and Services

- MoonGen packet generator
- Reproducible network experiments
- Packet processing and forwarding in software

Talk to me about...

- Do you use a packet generator?
 - Which one?
 - For what?
 - How do you use it?
 - Which features do you care about?
 - What can be improved?
- · Software packet processing systems that I've worked on
 - For example: high-speed packet capturing at > 100 Gbit/s
 - See poster for details

Vaibhav Bajpai

PhD / Postdoctoral Researcher — *advised by Prof. Dr. Jürgen Schönwälder*

[- 2016]

Postdoctoral Researcher — *advised by Prof. Dr. Jörg Ott*

[2017 -]

Research

see: www.vaibhavbajpai.com

- Performance Measurement Platforms
 [COMST 2015] [CCR 2015] [IM 2017] [ietf-lmap-yang,-restconf]
- Measuring IPv6 Performance
 [PAM 2015] [NETWORKING 2015] [ANRW 2016] [CNSM 2016]
- Dissecting Last-mile Latency Characteristics
- NetFlow / IPFIX Flow Analysis
 [TNSM 2017] [IM 2013]

- ▶ What can DNSSEC (~3%) learn from IPv6 (~15%) adoption?
- *How can we get corporate networks to adopt IPv6?*

• *Can we simply leave Internet innovation to large CDN players?*

Introduction & Research

- Dr. Matthias Wachs
- Chair of Network Architectures and Services

- Secure and privacy-preserving communication: Project "TUM Secure E-Mail and User Certification"
- Impact of emerging communication services: Security & privacy of mobile plattforms & messaging
- Decentralization and adaptable architectures: Improving network security & resilience through adaption
- Future Architectures & communication services

Open Questions

- What is today's state of networked services?
 - How can we evaluate resilience and security in the wild?
 - How can we improve security and resilience?
 - How do service paradigms change? What is the impact?
- How can we evolve today's systems?
 - How can we achieve usable security by design?
 - · What building blocks, protocols and systems do we need?
- What are requirements for future (communication) services?
- How can we design reliable services and networks?
 - What are requirements? Cooperation? Adaption?
 - What is a design for resilient, adaptive, cooperative systems and services?

Jörg Ott

- TUM, CS, Chair of Connected Mobility
- Working on
 - Mobile connectivity and service platforms (Living Lab Connected Mobility)

- Cloud transport and service infrastructure (EC H2020 SSICLOPS)
- Internet for All: architectures and services (EC H2020 RIFE)
- End-to-end measurements (EC FP7 ITN METRICS)
- WebRTC real-time measurements (callstats.io)
- Meta themes
 - Network architecture (DTN, ICN, ...)
 - IP multimedia transport
 - Measurements; mobility and user behavior modeling; QoE
 - Connecting (mobile) things and mobile users and maintaining privacy

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Some questions

- Future Internet transport
- Lessons from ICN and DTN for Internet protocols
- New architectures and deployability

• Sensible modes of operation for MIR³

Christian Prehofer

Working on

- Adaptive Cyber-physical Systems
 - Security & safety
- Open, secure platforms & trusted apps
- Internet of Things

Things to discuss

- System Security and Internet of Things
- Security by design
- Runtime Adaptation & Safety

Dr. Lars Eggert

Technical Director, Networking, NetApp

History

2011– NetApp
2007–11 Nokia
2003–07 NEC
2003 Ph.D., USC/ISI

Academic

SIGCOMM, boards, 90+ PCs

IETF

- 2016– QUIC WG chair
- 2011–17 IRTF chair
- 2006–11 Transport AD

NetApp

Pane

TUM LKN: Dr. Péter Babarczi

Post-Doctoral Research Associate

MTA-BME Future Internet Research Group

Budapest University of Technology and Economics, Hungary

Humboldt Post-Doctoral Research Fellowship @ TUM LKN (from 2017)

() TT

- J. Tapolcai, P-H. Ho, P. Babarczi, and L. Rónyai, Neighborhood Failure Localization in All-Optical Networks via Monitoring Trails, IEEE/ACM Transactions on Networking, 2015.
- J. Tapolcai, J. Bíró, P. Babarczi, A. Gulyás, Z.Heszberger, and D. Trossen, Optimal False-Positive-Free Bloom Filter Design for Scalable Multicast Forwarding, IEEE/ACM Transactions on Networking, 2015.
- P. Babarczi, J. Tapolcai, and P-H. Ho, *Adjacent Link Failure Localization with Monitoring Trails in All-Optical Mesh Networks*, IEEE/ACM Transactions on Networking, 2011.

- Scalable and efficient multipath Internet routing
 - Independent spanning trees
 - End-host based path selection
- Instantaneous failure recovery in transport networks
 - Network coding/diversity coding
 - No flow rerouting or packet retransmission upon failure
- All-optical failure localization with supervisory lightpaths
 - Support fast protection switching

Alert-based reconfiguration of virtual SDN networks

LKN: Andreas Blenk

Topic: Analysis, Modeling, and Optimization for Dynamic and Software-Defined Virtual Networks

Research Scenario

- Combine Network Virtualization (NV) + Software Defined Networking (SDN)
- Provide control to virtual network tenants
- Dynamically changing virtual network environments

Research Goals

- Models for Optimization of Data/Control Plane Resources in Virtual (SDN) Environments
- Design of Adaptive Network Virtualization Layer (SDN Network Hypervisors)

Methodologies & Results

Methodologies Applied

- Simulation-based Analysis [1,3,4]
- Linear/Mixed Integer Programming [1,3]
- Network Analytics (Machine Learning) [4]
- Neural Networks for System Optimization [4]
- Graph Features-based Analysis [4]
- Network Measurements [2]
- Architecture Design & Protocols [2]
- Proof of Concept Implementation [2]

Feedback on Results?

- Analyze trade offs: reconfigurations vs network utilization [1]
- SDN-based network virtualization architecture design
 [2]
- Models for analyzing SDN network hypervisors [3]
- POSTER: Neural Network-based admission control for Virtual Network Embedding [4]

[1] Blenk, A., & Kellerer, W. Traffic pattern based virtual network embedding. In Proceedings of ACM CoNEXT Student Workshop 2013

[2] Blenk, A., Basta, A., Kellerer, W. HyperFlex: An SDN Virtualization Architecture with Flexible Hypervisor Function Allocation. IFIP/IEEE International Symposium on Integrated Network Management (IM 2015)

[3] Blenk, A., Basta, A. Zerwas, J., Reisslein, M., Kellerer, W. Control Plane Latency with SDN Network Hypervisors: The Cost of Virtualization, IEEE Transactions on Network and Service Management, vol. 13, no. 3, pp. 366 - 380, September 2016.

[4] Blenk, A., Kalmbach, P., van der Smagt, P., Kellerer, W. Boost Online Virtual Network Embedding: Using Neural Networks for Admission Control, CNSM, Montreal, Quebec, Canada, Oktober 2016.

Georg Carle: Research Interests

Topics

Network measurements

- Packet processing performance
- Internet-wide properties

Network architecture

- Network security and privacy
- Network resilience
- Network virtualization
- Low-latency communication

Methods

Automated performance measurements in testbed Large-scale distributed measurements Formal methods for network security functions

Georg Carle - Raitenhaslach, 24.11.2016

Topics for Discussions

SDN and Virtualisation

- Can we predict how SDN will be deployed?
- What are relevant research challenges for SDN?
- What are relevant research challenges for NFV?
- Are we satisfied with the security properties of SDN?

High performance packet processing

- Which limits exist for software packet processing?
- Which role do reprogrammable hardware components / FPGAs have in the network stack?

Reproducibility

- What are suitable reference scenarios?
- Are we aware network experiments that are hard to reproduce? What is the future relevance of the following Hot Internet Topics?
- Information-Centric Networking; Delay-Tolerant Networking; Resource Public Key Infrastructure (RPKI); ...

Georg Carle - Raitenhaslach, 24.11.2016

TUM LKN: Markus Klügel

Device-to-Device Communication

Scenario:

- Direct communication in cellular networks
- Allow dynamic frequency reuse

Known:

- D2D Produces 3 types of gains:
 - Proximity-gain, hop-gain and reuse-gain
- Resource reuse produces complex interference situations

Active Research Questions:

- How to measure the "gains" of D2D?
- How much service penetration is needed for D2D to happen?
- How to precondition links for frequency reuse?

TUM LKN: Markus Klügel

Device-to-Device Communication

POSTER: Operation and Control of Device-to-Device Communication

Featuring:

- The ability of Sum-Rate to capture network "quality"
- A saturation effect on D2D-link density
- Insights on Interference Management basics

Open to discuss:

How far can we push SD"X" into wireless domain?

TUM LKN: Alberto Martínez Alba

Flexibility in Software Defined and Virtualized Wireless Networks

Research keynotes:

- Measuring flexibility of wireless networks
- Focus on mobile wireless networks enhanced by:
 - Software Defined Networks
 - Network Virtualization
 - 5G technologies

Figure: Example of a combination of SDN, NV and other 5G proposals that could enhance the flexibility of mobile networks

TUM LKN: Alberto Martínez Alba

Flexibility in Software Defined and Virtualized Wireless Networks

Open questions:

- How wireless networks can be virtualized and/or software defined
- How to **measure flexibility** of wireless networks
- How 5G proposals can **improve flexibility**
 - e.g. Coordinated MultiPoint, massive MIMO, D2D, etc.
- Derive guidelines to design flexible wireless networks

TUM LKN: Nemanja Đerić

Design and Analysis of Function Placement Strategies for Future Mobile Networks

Main Focus:

- Future Mobile Networks (5G)
- Challenges of Distributed Cloud Architecture
- Software Defined Networking (SDN) & Network Functions Virtualization (NFV)

TUM LKN: Nemanja Đerić

Design and Analysis of Function Placement Strategies for Future Mobile Networks

Research Topics:

- Flexible Network Functions Placement
- Network Virtualization
- Network Slicing
- Data Center Placement
- Distributed Cloud Architecture

Introduction & Research

- · Heiko Niedermayer
- Chair of Network Architectures and Services

- Network Security
- Resilience
- Modeling and Data Analysis

- Do multipath methods make sense on Internet-wide level due to hidden backup links?
- Do we want certificate transparency or other forms of enhanced certificate protection in cases of client certificates?
- Can we model and predict performance and robustness of cloud services and cloud communication?

Introduction & Research

- Minoo Rouhi
- Chair of Network Architectures and Services

- Large-scale Internet Measurements
- IPv4/IPv6 Sibling Validation

Open Questions

- · IP sibling validation and sibling-based path tracing
 - Reducing measurement efforts
 - Automation of sibling acquisition
 - Smart learning of discerning metrics
- Detecting and analyzing network topologies
 - · Reproducing network topologies in a virtualized testbed
 - Analysis of network bottlenecks

Introduction & Research

- Sebastian Gallenmüller
- Chair of Network Architectures and Services

- Measurements of systems for packet processing
- Packet processing in software
- Reproducible network experiments

Open Questions

- Measuring and modeling of a networked cyber-physical system (nCPS)
- Building a testbed for reproducible wireless measurements
 - Integrate the wireless hardware into the Baltikum testbed
 - Integrate precise energy measurement setup
- Set up a control system as an example for a nCPS
 - Software simulation of a two way inverted pendulum (Segway)
 - Prepare for measurements of a hardware nCPS

Introduction & Research

- Johannes Naab
- Chair of Network Architectures and Services
- DNS
- Flow (as in IPFIX) Monitoring
- Anomaly Detection, Intrusion Detection Systems
- Poster: DNS Research
- Poster: AutoMon Automatisiertes Performance-Monitoring

Open Questions

- Large Scale DNS monitoring/scanning
 - Only for the sake of DNS? What are other use cases?
 - Public/reliable domain name sources other than Alexa, Zone files, certificates, and reverse DNS?
- (Distributed) Denial of Service Attacks
 - Defenses beyond centralization? Which mitigations are possible without moving behind content delivery networks and "security" providers like Cloudflare?